EATON'S

GEOLOGICAL TEXT-BOOK.

[With Map, &c. Price One Dollar.]

Horace Webster

GEOLOGICAL TEXT-BOOK,

PREPARED FOR

POPULAR LECTURES

ON

NORTH AMERICAN GEOLOGY;

WITH APPLICATIONS TO

AGRICULTURE AND THE ARTS.

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PREFACE.

EVERY geologist is, probably, more or less misled by theory. If the earth was washed and the rocks left clean, they would not disagree in regard to rocks. But they are now dependent on naked cliffs and deep river-washed ravines; which present to the eye less than a hundreth of the evidence required. For ninety-nine hundredths, theory alone furnishes the facts upon which the very *same theory* is founded. But a long course of observations and careful comparisons, have done considerable towards a correct system of generalization.

Geology is subject to an evil peculiar to itself. If its votaries disagree, the common learner has neither time nor inclination to review their data, by visiting localities referred to, and thus to correct their mistakes and adjust their differences. The reasons, fully written out, which govern the experienced geologist, would require numerous octavos for each stratum. Therefore the learner must rely upon his confidence in his teacher's habits of careful investigation, his fidelity, his independence, and his talent at generalization. He must not overlook the advantages presented by the district of country which he examines. He should therefore compare the districts examined by different geologists.

The little island of Britain can furnish no authority for a *general system*; though the industry of distinguished geologists has done much towards an elucidation of important points, in detail. France, taking in the Alps as a primitive nucleus, presents more advantages. But according to De Luc, America alone must give a *system of general strata.* How far I have succeeded in my attempt to present such a system, future investigations (not the opinions and closet speculations of the geologists of either continent) must decide. For the system adopted in this text-book, I rely on my own personal examinations, aided by Dr. T. R. and Prof. L. C. Beck, M. H. Webster, and J. Eights, more or less supported by Professors Hitchcock, Dewey, and Emmons, from the Atlantic to the western extremity of Lake Erie. For the remainder, I rely upon the personal examinations and collected specimens, which I have now before me, of Dr. Zina Pitcher and Dr. Edwin James. Messrs. Schoolcraft and Peter have also contributed much. We have, altogether, traversed a succession of northerly and southerly strata through more than forty degrees of longitude.

A *text-book* is too small a name for these days of puffing arrogance. But I propose to present all my *supposed heresies* to the geological fraternity in this form and under this title. And I beg the favor of the most rigorous criticism upon this book, small as it is. To stimulate men of science to the work of examination and of criticism, I will state; that I intend to publish considerable in scientific journals, also a full system, upon this plan. As I have had more than seven thousand pupils already,* and shall probably have more still, it will be well for them "to be on the alert" if I am propagating errors. I am not in sport—I have, during the last fifteen years, travelled over seventeen thousand miles, for the express purpose of collecting geological materials; the results of which are comprised in this little octavo pamphlet, and exhibited in the accompanying map and wood cuts.

* Rather, auditors.

I may be accused of fickleness on account of the changes which appear in every successive book I publish. I confess this is the ninth time I have published a geological nomenclature; and that I made changes in each of more or less importance. But I have always consulted my scientific friends; and every change was founded on new discoveries in "matters of fact." In this text-book, the principal changes relate to the graywackes. The Allegany mountains, I had never examined before with particular care. I verily think, these mountains present every thing required for settling that part of the science. The various deposites of Detritus had not been thoroughly studied by any American, when I published my last nomenclature. I believe I have made a few changes in that department, which will finally obtain. I now adopt the Tertiary formation of Europeans; but I find no facts here to justify their *numerous* subdivisions.

I can now give European equivalents for all our strata, excepting the ferriferous and geodiferous. Our *fourth series*, however, seems to be more solid, harsh, and vastly more extensive, than its supposed equivalent. Perhaps it is a repetition of our *third series*. It is certainly distinct in the range of the profile given at the foot of the map, however.

With all defference to the high character of La Bache; as an experienced teacher I may say, that his numerous subdivisions, if adopted, *will ruin the science*.* Others have done much towards driving the study from our schools, by introducing petty local names. If their authors were not entitled to high respect, on account of other services to the science, one would feel disposed to treat such names ludicrously. For example, there is a variety of first graywacke in a place called Pilfershire, in Columbia county, remark-

* See Table of Equivalents at the end of this Text-Book.

able for enduring heat. There is another in a place nick-named Fuddletown, in Onondaga county, of a cellular texture, much used at Salina. The former should be called *Pilfershire stone*, and the latter *Fuddletown stone*, to be equivalent, *in absurdity*, to Purbeck, Bagshot, and other ridiculous European names.

The distribution of strata into *five series*, cannot be called an innovation; for it produces no change whatever. It amounts to nothing more, than referring well established strata one step further back, towards an elementary basis.

Students, for whom this text-book is intended, may feel no interest in any thing *personal*, relating to myself. But I will throw this paragraph in their way. I have been accused of arrogance for stating facts relating to American geology, without formally bowing to European authorities. I should condemn myself for any step in the science, which was not taken with a due consideration of all that had been done in Europe, Asia and Africa, in advance of our own investigations in point of time. Whoever is "first in the field" of natural science, has an exclusive right *to give names*. His successors should either adopt his names, or give them as synonyms and equivalents. This is essential to the very being of science. But English and French geologists have introduced new names, not adopted in Germany; because new discoveries made them necessary. I have done the same thing in America, and for the same reasons.

I confess that this is a kind of "ipse dixit" text-book. It is so, because the plan does not admit of demonstration. In a future publication, I intend to cite authorities from nature to illustrate my views. But I am prepared to abandon any of them; as I have frequently done heretofore, in cases of numerous errors, to which I am still subject.

Geology is a progressive science ; and he, who has any respect for his future reputation, should be exceedingly cautious about committing himself on matters of fact or speculation. I confess, that I have, *most egregiously*, violated this rule ; but there are peculiar circumstances in my case, arising from my being " a hireling drudge" to the most munificent patron of this science, which will palliate, at least, if not justify.

I despise arrogance ; but I am within sixteen years of the "three score and ten," when the mind of man is averaged beyond the period of vigorous effort. About two score of these years have been devoted to Natural Science. I offer this as an apology for some dogmas, forbidden to youth.

AMOS EATON.

RENSSELAER SCHOOL, *Troy, N. Y.*
January 23, 1830.

GEOLOGICAL TEXT-BOOK.

CHARACTER AND OBJECTS OF GEOLOGY.

THE science of Geology consists in a systematic arrangement of facts, explaining the structure of the earth. Definition.

Our observations are limited to its exterior rind or coats. We know very little of its interior structure. But the inequalities of its surface often give us admission to a considerable depth; from which we should be totally excluded were its surface every where smooth like a pacific sea. Observations limited

Since the earth's specific gravity has been ascertained by suspending the plumb-line by the side of an insolated mountain rock, we infer that it must be made up of heavier materials interiorly than near its surface. For the whole mass of the earth is found to weigh about five times as much as an equal mass of water. Whereas all its exterior rind, from the surface to its greatest ascertained depth, taken in the aggregate, weighs but about half as much. Late experiments by Cordier and others, seem to lead us to important conclusions respecting the internal temperature of the earth. It is proved, that as we penetrate the earth, the temperature diminishes until we are below the limit of solar influence. And from that point the temperature increases at the rate of about one degree of Fahrenheit for every fifty feet. But it is not probable, on any hypothesis, that heat increases in this ratio to the center of the earth. If it did, the whole interior of the earth would be in the state of melted lava; leaving, according to Cordier, a solid crust less than one hundred miles in thickness—not exceeding in proportion the thickness of an egg-shell. Specific gravity of the earth. Internal heat.

External and internal heat diminishes.

As numerous observations seem to prove, that the surface of the earth is of a lower temperature than formerly, it may be in accordance with sound logic to suppose, that the cooling of a heated cannon ball will exemplify the gradual cooling of the earth. Therefore, as the cannon ball cools rapidly at its surface, without any material diminution of temperature at the depth of an inch for a long time; we may infer that after penetrating the earth to the depth of a few miles, we should arrive nearly to its maximum of heat.

Ancient theories.

Specific gravity and internal heat being all we know of the structure of the earth, excepting what we learn from inspecting its surface, the absurdity of ancient theories is manifest. But the tops of the most elevated ridges being about five miles higher than the deepest natural and artificial cavities, much has already been ascertained respecting the history and structure of the earth.

Earth penetrable five miles.

Utility of the study. 1st, as the most ancient history.

Geological facts lead us to the history of created beings, long anterior to written records. Such records may be erroneous, and we have no means for correcting them. But geological records are perpetual, unvarying, and cannot be vitiated by interpolations or counterfeits. For example, the written history of the deluge might be varied more or less by erroneous copies or incorrect translations. But the geological records of divine wrath poured out upon the rebellious inhabitants of the earth, at that awful period, can never be effaced nor changed. These latter records add, to the Mosaic account, that even the antediluvial beasts of the forests and fens partook of the ferocious nature and giant strength of antediluvial man.

Order of creation.

The order of creation too is stamped upon the ever-during rocks. There and there only we learn which of the grasses and of the herbs yielding seed, and of the fruit trees yielding fruit after its kind, was created first. For the acotyledonous tribe of ferns first appear in the oldest rocks containing organic relics, these are followed by the largest mono-cotyledonous tribe of grasses, canes and reeds. Here too we find the first created fruit-tree yielding fruit to be the ancient palm. No records but the geological could ever have brought to our knowledge the known truth, that no cauline or dicotyledonous plants were created, until all rock strata were finished ; nor that man was created later than cauline plants.

Earliest works of the Creator.

Whoever feels an interest in the works of creative intelligence, must be delighted to trace those works from that early period of time which is far beyond the highest recorded limits of antiquity. This enrapturing pursuit is within the reach of none but the geologist.

2d. In searching for useful minerals.

Geology teaches us that minerals which are associated in one district of country are associated in the same order in all other districts. Hence the experience of the miner and the quarry-man in any country may be applied in searching for useful minerals in all countries. But here the aid of the scientific geologist is necessary ; for *geology is the true science of mining.* As in all other cases of the kind, the facts which accident presents to the artist, must be collected and generalized by the man of science ; and then presented to all artists of the same profession. For example, the discoveries of gold in the talcose slate of the Carolinas, will serve as an index to the miner, pointing to the whole range of talcose slate from Georgia to Canada, by way of New-York and the Green Mountains of Vermont.

3d. In judging of, and improving, soils.

From the general composition and character of every kind of detritus, we are enabled to judge of the fertility of soils, and to apply correctives in cases of barrenness. For example, whenever we find marine sand, which is now known to be a very extensive stratum, we can always find the marley clay beneath it. This will induce the agriculturist to apply an efficient corrective for improving his barren sands, by raising the marley clay from pits, and applying it to the surface as his situation may afford the means.

4th. In the study of physical geography.

Mountains, valleys, beds of oceans, seas, lakes and rivers, are all referable for their origin to geological changes. The soft saliferous and carboniferous rocks, in which the bed of Lake Ontario is made by the rapid disintegration of those rocks, is an example. The beds of Lake Champlain, the Mohawk river and of the Hudson through most of its extent, were made by the disintegration of rocks at the meeting of different formations. The deep bed of the Hudson across the Highlands, which is chiefly hornblende rock, may, without extravagance, be ascribed to the fusion by volcanic heat which produced the basaltic Palisadoes below the chasm. The same hypothesis may be well applied to the channel of Connecticut river, north of the northern line of Massachusetts, whence the volcanic lava flowed which now forms a series of basaltic prominences from Vermont to Long Island Sound. Hence one important part of physical geography may be explained by a reference to disintegration, decomposition, volcanic action, and other geological agencies.

CONCISE HISTORY OF GEOLOGY.

Geology originally a creature of fancy.

The name geology was originally applied to visions, which floated in the fancies of men, respecting the original production of the earth. No facts were adduced in proof of hypothesis, excepting the few which presented themselves to, or rather enforced themselves upon the senses, without the labor of research. *Possibility*, without even the shadow of *probability*, seems to have been received as conclusive evidence.

Commencement of geology as a science. Lehman.

We are indebted to the Germans for geology as a science. Lehman first published the fortunate suggestion, which elevated geology to the dignity of a science. He first called the attention of the learned to a new view of creative intelligence in the systematic arrangement of the solid contents of the apparently amorphous earth. The illustrious Werner improved upon the thought. Through a long life, by uniting study, theory and practice, and directing all the energies of his mind

Werner.

to a single object, he gave character and great interest to this department of nature. He led his numerous pupils into the hitherto dark regions of the earth, which his mighty genius had now illuminated. Though he was somewhat bewildered by the mazes of fancy and yielded too far to the visionary theories of his time, his classification of facts must ever form the basis of all future geological enquiries.

Saussure, De Luc, Humboldt, Kirwan, Jameson, and others, improved upon Werner by the aid of additional facts. These facts Werner lived to apply as correctives of his early mistakes, and to fill up the chasm in his own discoveries. He closed his long life in the full splendor of his scientific glory, in the same year (1817) in which we began to make our humble efforts in the application of his views to American earth. **Dutch, French and British geologists.**

Hutton had done much in the life time of Werner. But his theoretical views were at variance with those of Werner; and much overheated controversy existed between their respective pupils. Werner ascribed most geological phenomena to the agency of water, while Hutton referred the same to the action of internal heat. Hutton died in an unhappy state of mind, at a time, when his views were almost universally rejected; but Werner died amidst the universal plaudits of his favorite views. Scarcely had that earth, which he had studied with such interest and applause, received his manes, when his theory was reviewed, and began to be received with less approbation. **Hutton.**

At length the illustrious Cuvier came before us. He balanced the two theories with a giant hand. He demonstrated the Huttonian theory in its application to many phenomena; but left much to be explained upon the Wernerian. He relied solely on well established facts, and proceeded cautiously in his theoretical views. Bakewell, Brongniart, M'Clure, M'Culloch, Greenough, Phillips, Conybeare, with numerous others, constituting a brilliant constellation of resplendent luminaries, now began to enlighten both *subterranean* hemis- **Cuvier.**

pheres; while the *very exterior surface* of the earth was scarcely considered.

Such was the general state of geological science at the close of the first score of years in the present century. Since that time Buckland, aided by the veteran Cuvier, has commanded the whole geological phalanx to leave for a while the deep abodes of rocks, and to examine "the open caverns and the furrowed earth." He has led out before us, from the cave of Kirkdale, the antidiluvial mastodon, chased and gnawed by hundreds of hyenas. He has shewn us the torrid abodes of the river horse and the elephant to have been in the latitudes of Caladonia and Scythia. The deluge no longer rests on the authority of written evidence. He points to records as durable as the earth, and far less changeable. The study of organized beings has become the most essential qualification for the study of geology; for their relics are the more sure guides to truth.

Buckland. Geology extended to detritus.

Antidiluvial remains

But in the midst of these splendid discoveries, which overwhelm the strongest imagination with wonder and amazement, some reformation seems to be required; even among those rocks where Lehman and Werner begun their labors. This humble task has occupied many a weary hour of several Americans, who feel zealous in the cause of their own indigenous geology. And we have a Morton, a Cooper, and a few others, among us, who are pursuing the course marked out by Cuvier and Buckland.

Reformation required in rock strata.

GEOLOGICAL DEPOSITES.

The earth is composed of masses of rocks and detritus, which are more or less extensive and uniform in their characteristic constituents. At least such is the exterior structure of the earth, from its outer surface to the greatest depths to which it has been laid open for inspection. These masses are mostly in *regular deposites ;* and those of the same structure and composition regard the same order of superposition in relation to each other. A few of the outermost masses are independent *anomalous deposites,* having no reference to each other. Regular and anomalous deposites.

As those deposites which are *geologically* the lowest are mostly highly elevated, and more universal than the superimposed ones, and always form the most prominent superficial starting points, we begin with them in a *geological nomenclature.* Primitive rocks the starting point.

REGULAR DEPOSITES,

Are distributed into five Series, called Classes. Each series consists of *three formations,* which formations are found to be *corresponding equivalents* in all the series. The lowest formation in each series is *slaty* or *argillaceous,* and always contains beds of *carbon* in the state of coal, anthracite, or plumbago. The next is *silicious,* and destitute of beds of carbon. The uppermost is chiefly *carbonate of lime,* also destitute of beds of carbon. But each formation embraces beds, alternating layers, veins, and disseminations of mineral bodies, often of great extent, which are not essential constituents of it. In some cases, however, they are so abundant and so striking in their characters, that they give names to general strata ; as metalliferous, ferriferous, saliferous, &c. Five series. Three formations.

HYPOTHESIS OF REGULAR DEPOSITES.

Hypothesis. The memory is aided by hypothesis ; as the fancy is thereby made a profitable auxiliary. Hypothesis must never be at variance with fact ; and must be changed from time to time, so as to accord with all new discoveries. The following hypothesis will be adopted in this text-book ; but I am not bound to support it any further, than to prevent any discordance between it and well attested facts.

Hypothesis must accord with fact.

Primitive deposites contain the elements of all others. All the primitive formations were deposited, and the lower part of the argillite, in the form of concentric spheres, like the coats of an onion. These deposites contained the materials of which all outer formations were afterwards made. Soon after these deposites were made, they were broken up through several northerly and southerly rents, by a very great force exerted immediately beneath the lowest of the primitive strata. In this semi-indurated and broken state, materials were readily furnished for the outer strata. There may have been several great explosions ; but this is sufficient for our present purpose.

Were broken up.

Probably several times.

EXHIBITION OF TWO TRANSVERSE SEGMENTS.

The earth is here supposed to be cut into two parts, at the 42° of north latitude.

The observer is supposed to stand south of the center of the segments—all the earth, south of him, being removed.

EXPLANATIONS.

Formations.

Figures 1 and 2.* A. Lower carboniferous formation—E. Lower quartzose formation—I. Lower calcareous formation—O. The lower side of the second carboniferous formation when used in Fig. 1. This lower part is probably primitive. When used in Fig. 2, it is for all that formation—U. Second quartzose formation—X. Second calcareous formation—W. Oceanic waters.

Combustibles.

These are indicated by numeral figures. In Fig. 1, they are represented as they are supposed to have been deposited at the creation. In Fig. 2, they are represented as having been consumed by combustion, whereby an explosion was produced, which burst through the primitive and transition series—the only deposites then made; and those not perfectly indurated. 1. The combustibles under Rocky Mt.—2. New-England—3. Britain—4. Alps and Pyrennes—5. Caucasus—6. Himalay.

Remarks. In Fig. 1, the water is represented as encompassing the whole earth; being pressed out to the surface by the greater specific gravity of the earthy materials. While the earth and waters were in this quiescent state, no organized beings, but marine, were provided with a place of residence. In due time the combustible materials marked 1, 2, 3, 4, 5, 6, were ignited, and produced the changes exhibited in Fig. 2.

* These figures are an improvement upon those published in my Geological Index, in 1820, and afterwards copied into Woodbridge's Geography.

Fig. 1.

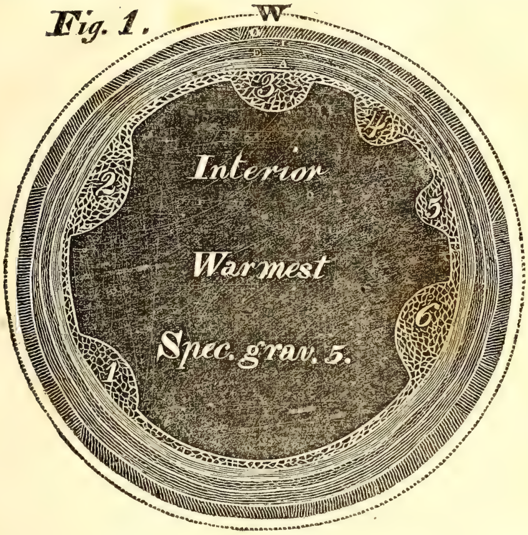
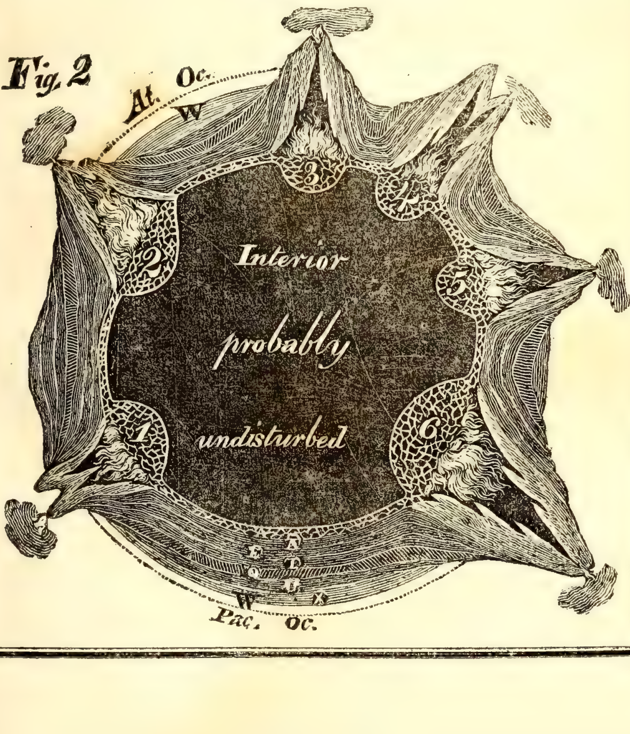

W
3
4
2
5
6
1
Interior
Warmest
Spec. grav. 5.

Fig. 2


At. Oc.
W
3
4
2
5
1
6
Interior
probably
undisturbed
W
Pac. Oc.

EXHIBITION OF A TRANSVERSE SEGMENT.

The continent of North America is here supposed to be cut into two parts between the 42° and 43° north latitude.

The observer is supposed to stand south of the middle of the segment—that part of the continent which is south of him being removed.

EXPLANATIONS.

Fig. 3. This figure represents a segment of the earth from the Atlantic to the Pacific, between the 42° and 43° N. latitude, in its present state, so far as regards rock strata. The tertiary formation, or antidiluvial detritus, may be supposed to overlay the rock strata in most of the depressed situations. The 3d and 4th series may be supposed to have been mostly deposited after the great explosion, represented on Fig. 2; and the tirtiary, or 5th series, to have been deposited last of all the regular series. All strata above the lower side of the argillite, may be supposed to be made up by the abrasions and disintegrations of the then soft concentric strata, represented in Fig. 1. For, as we may suppose them broken up soon after their deposition, they were in a semi-indurated state, and readily washed from their original situation, by the numerous currants which the uneven surface would then cause.

Abbreviations.

Car. Carboniferous formations—Qu. Quartzose formations —Cal. Calcareous formations. The numerals indicate the first, second, third, fourth and fifth series of formations. The fifth, however, is not represented here. See definition of it, fifth series.

Remarks. In Fig. 3, the present state of the earth is represented, after several vast explosions; as, according to Cuvier's theory, "life has often been disturbed on this earth by terrible events." The combustible materials are now supposed to be too nearly exhausted to produce such general explosions; but are still sufficient for ordinary earthquakes.

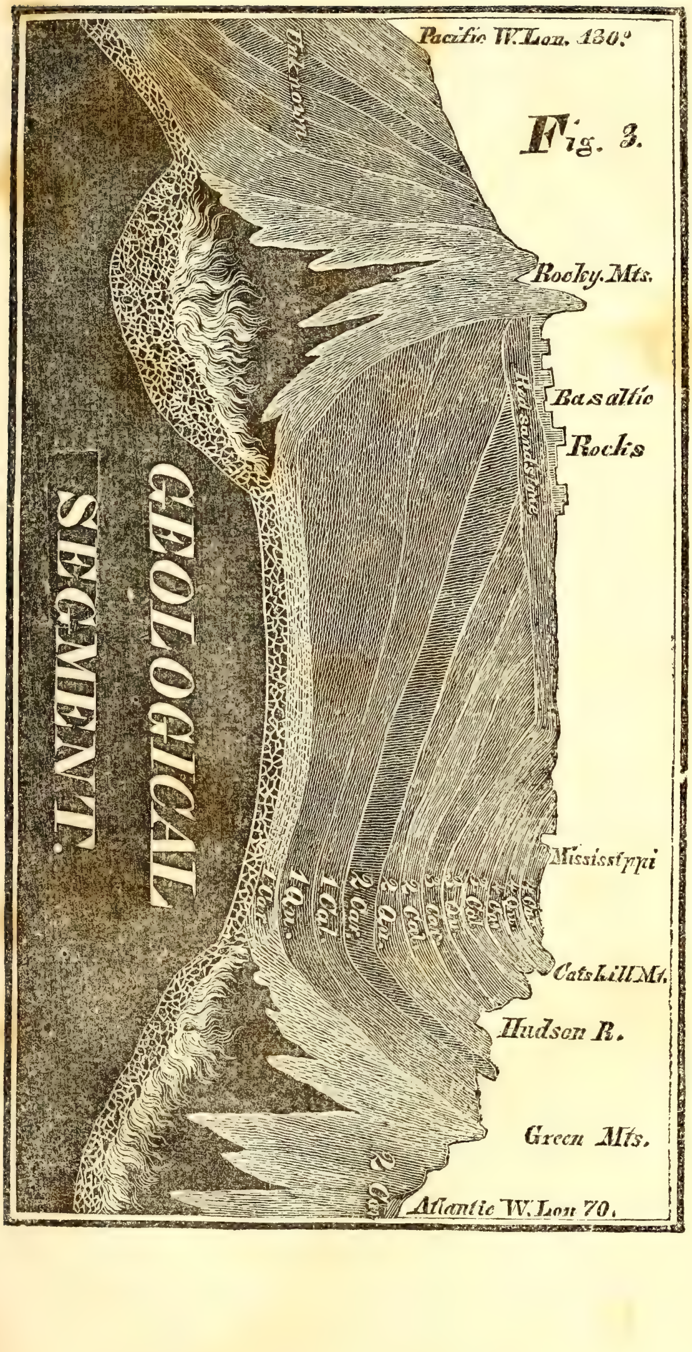

Pacific W. Lon. 130°
Rocky Mts.
Basaltic
Rocks
Mississippi
Catskill Mt.
Hudson R.
Green Mts.
Atlantic W. Lon 70.
GEOLOGICAL
SEGMENT.

Fig. 3.

HYPOTHESIS.

The hypothesis here proposed will not explain the several advances and retreats of salt and fresh water, the latter on dry land of course. It is true, we are authorized to suppose large cavities formed in the earth by the elevation of rocks, which would receive much water. We may imagine, that these rocks fell back more or less, and were raised again, several times in succession ; and that the water would enter into, and return from, these cavities, at every such change. But we have no conclusive evidence of such wonderful changees.

Hypothesis will not explain fresh and salt water alterations.

Other hypothesis, of equal plausibility and equally void of demonstrative support, might be proposed. But, though many phenomena may now be explained, more facts must be collected before tenable theories can be proposed.

The characters and relative ages of geological depositions, whether we call them strata, formations, series, or classes, must be studied in their individual and collective states. It appears most expedient to present the first view of them under the general heads, of classes or series.

Ages of strata.

DEFINITIONS OF CLASSES.

Classes.

Of Regular Deposites.

Class i. *Primitive Class, or First Series*, includes those rock strata, which never contain organic relics, and never repose on rocks which do contain such relics.

No relics.

Class ii. *Transition Class, or Second Series*, includes those rock strata which contain animal and vegetable relics : but the animal relics are always of the radiated kind, or molluscus with more than one valve, or one-valved and (generally if not always) chambered ; and the vegetable relics are mostly acotyledonous and stiped—rarely monocotyledonous and culmiferous.

Oldest relics ; as chambered mollusci.

Class iii. *Lower Secondary Class, or Third Series*, includes those rock strata which, in addition to the relics of the

Univalves not chambered.

second class, contain univalves *not chambered*, with stiped and mostly culmiferous monocotyledonous vegetables.

Oviparous vertebrals.

CLASS IV. *Upper Secondary Class, or Fourth Series,* includes those strata which, in addition to the relics of the third class, contain *oviparous vertebral animals.*

Viviparous vertebrals.

CLASS V. *Tertiary Class, or Fifth Series*, includes those strata which, in addition to the relics of the fourth class, contain *viviparous vertebral animals.* Mostly not indurated.

ANOMALOUS DEPOSITES,

Anomalous.

Are those which are produced at the earth's surface by the *fusion* or *disintegration* of regular strata.

Later explosions.

1. VOLCANIC DEPOSITES. Hornblende basaltic rocks, deposited since the primitive explosion and before the deluge ; or more recent deposites of lava, breccia, ashes, stones, &c. produced by the direct action of volcanic heat upon the substance of the deposites.

Noah's deluge.

II. DILUVION. Subdivisions. PROPER DILUVION is a confused mixture of gravel, sand, clay, loam, plants, animals, &c. so situated that it must have been deposited from water in a state of violent action, which could not have been produced by any existing cause : or it must agree in character with deposites which are thus situated. Never contains works of art. ULTIMATE DILUVION, a thin deposite of greyish yellow loam, reposing on other strata, in all ancient uncultivated forests, which have not been cut away since the deluge. It is so situated, that it cannot have been deposited from water while running with much velocity ; but appears to be the last settlings of a deluge.

No works of art.

Present deposites.

III. POST DILUVION.* Any detritus deposited by water since the deluge ; which is distinguished by the coarser pebbles being nearest to, and the finer sediment remotest from, the

* Very absurdly called *alluvion ;* as this is a generic term of long standing.

source of water which made the deposites. May contain works of art. Contain works of art

IV. ANALLUVION. Any detritus which has not been washed from the place of its first disintegration ; it being the pulverized surface of the underlaying rock. Present deposites of soil.

GEOLOGICAL SYNOPSIS ;

Exhibiting each stratum by a wood cut figure.

All general strata, are arranged under their respective classes, or series ; proceeding from the bottom of each page to the top.

Five classes of regular strata are adopted ; for the secondary class is, with great propriety, divided into *upper* and *lower*, by late European geologists. This accords with the distribution of strata into series of *ternary formations.*

The *numbers* and *abbreviations* in the left column, indicate the numbers of the series and classes, to which each formation belongs. Carb. is an abbreviation of carboniferous formation—Qu. the quartzose formation—Calc. the calcareous formation.

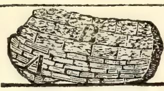
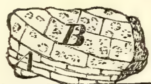
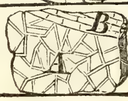
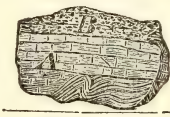
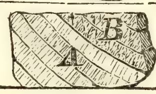
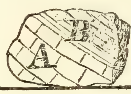
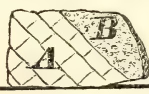
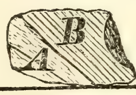
The *wood cut figures* in the second column represent the strata of each series or class.

The *small capitals* in the third column against the top of each figure, express the name of the general stratum. The italics under it express the names of the subdivisions.

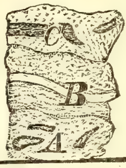
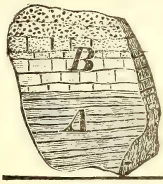
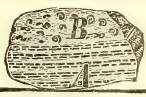
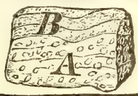
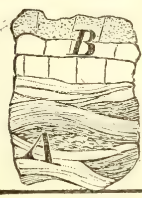
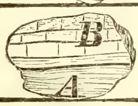
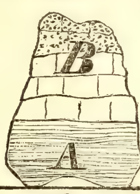
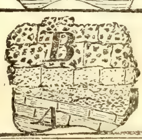
The fourth column contains the names of the most important varieties and most extensive beds embraced in the strata.

Anomalous deposites are not classified ; because the agreement in character, among them, will not authorize any systematic arrangement.

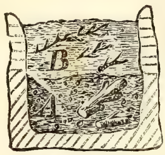
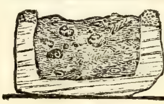
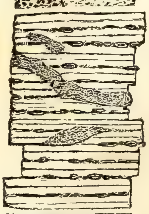
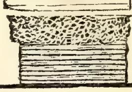
SYNOPSIS.

CLASSES OR SERIES.	WOOD CUT SPECIMENS.	STRATA AND SUBDIVISIONS.	VARIETIES.
2. Calc.		11. METTALLIFEROUS LIME ROCK. B. *Shelly.* A. *Compact.*	Cherty. Birdseye marble.
		10. CALCIFEROUS SANDROCK. B. *Geodiferous.* A. *Compact*	Opalaceous. Quartzose. Sparry. Oolitic.
		9. SPARRY LIME-ROCK. B. *Slaty.* A. *Compact.*	Checkered rock.
2. Qu.		8. FIRST GRAY-WACKE. B. *Millstone grit.* A. *Grey rubble and slate.*	Red sandstone. Grit slate. Chloritic.
2. Carb.		7. ARGILLITE. B. *Wacke Slate.* A. *Clay Slate.*	Chloritic. Glazed. Roof-slate. Red. Purple.
Here Organic Relics commence.			
1. Calc.		6. GRANULAR LIME-ROCK. B. *Sandy.* A. *Compact.*	Verd-antique. Dolomite. Statuary marble.
1. Qu.		5. GRANULAR QUARTZ. B. *Sandy.* A. *Compact.*	Ferruginous. Yellowish. Translucent.
1. Carb.		4. TALCOSE SLATE. B. *Fissile.* A. *Compact.*	Steatite. Chloritic.
		3. HORNBLENDE ROCK. B. *Slaty.* A. *Granitic.*	Greenstone. Gneissoid. Porphyritic. Sienitic.
		2. MICA-SLATE. B. *Fissile.* A. *Compact.*	
		1. GRANITE. B. *Slaty,* (gneiss) A. *Crystalline.*	Sandy. Porphyritic. Graphic.

SYNOPSIS.

SERIES.	SPECIMENS.	STRATA.	VARIETIES.
4. Calc.		19. OOLITIC ROCKS. C. *Chalk.* B. *Oolite.* A. *Silicious limestone.*	
4. Qu. 4. Carb.		18. THIRD GRAY-WACKE. B. *Millstone grit and grey rubble.* A. *Slate.*	Calc. pyriferous grit. Red sandstone. Red wacke. Pyritiferous slate.
3. Calc.		17. CORNITIFEROUS LIMEROCK. B. *Shelly.* A. *Compact.*	Cherty. Stratified.
		16. GEODIFEROUS LIMEROCK. B. *Sandy.* A. *Swinestone.*	Foetid.
		Belongs to 3. Qu.	Shell grit.
Subordinate.		15. LIAS. B. *Calcareous.* A. *Argillaceous.*	Vermicular. Shelly.
		14. FERRIFEROUS ROCK. B. *Sandy.* A. *Slaty.*	Conglomerate. Green. Blue.
3. Qu.		13. SALIFEROUS ROCK. B. *Sandy.* A. *Marle-slate.*	Conglomerate. Grey-band. Red-sandy. Grey slate. Red slate.
3. Carb.		12. SECOND GRAY-WACKE. B. *Millstone grit and grey rubble.* A. *Slate.*	Red sandstone. Red wacke. Hone slate. Conchoidal. Micaceous.

SYNOPSIS.

SERIES.	SPECIMENS.	STRATA.	VARIETIES.
		28. ANALLUVION. B. *Granulated.* A. *Argillaceous.*	
Anomalous.		27. POST DILUVION. B. *Fine sediment.* A. *Pebbles or gravel.*	
		26. ULTIMATE DILUVION.	Yellowish grey, sandy. Greyish yellow, loamy.
		25. PROPER DILUVION.	Sand. Gravel. Vegetable mould.
		24. VOLCANIC. B. *Basalt.* A. *Lava, Breccia, Trachyte.*	
5 Calc.		23. SHELL MARLE	Stratified with tufa.
5 Qu.		22. MARINE SAND AND CRAG.	
5 Carb.		21. MARLY CLAY.	Marl-beds, with organic relics. Iron stone. Lignite.
		20. PLASTIC CLAY.	Pipe-clay.

DESCRIPTIONS OF STRATA, ACCORDING TO THE FOREGOING SERIES.*

Class. I. *Primitive, or First Series.*

1. Carboniferous formation.

1. Granite, is an aggregate of angular masses of quartz, felspar, and mica. Subdivisions. It is called *crystalline* (granite proper) when the felspar and quartz present a crystalline, not a slaty, form. It is called *slaty* (gneiss) when the mica is so interposed in layers as to present a slaty form.—Varieties. It is *graphic* when the felspar is in a large proportion, and the quartz is arranged in oblong masses, so as to present an appearance resembling Chinese letters. It is *porphyritic* when spotted with cuboid blocks of felspar. This variety is peculiar to the slaty division.

Localities.—McComb's Mts.† At West Point we find as extensive layers of crystalline granite, as at any place which I have visited. Here it always alternates with the slaty subdivision (gneiss.) It is the same at Chesterfield, Goshen, Southampton, Russel, Spencer, &c. in Massachusetts. Also in Haddam, Litchfield, Norfolk, &c. in Connecticut. These

* Every rock consists, *essentially*, of one, two or three, of the following nine homogeneous minerals. These are called the *geological alphabet*; and every student *must* procure, and familiarize himself with, a specimen of each, before he commences the study of geology—quartz, felspar, mica, talc, hornblende, argillite, limestone, gypsum, chlorite. He should procure also a specimen of iron pyrites, hornstone, calc spar, reddle ore, bog-ore, glance coal, bituminous coal, and plumbago.

† It appears by the map, that the primitive rocks of McComb's Mts. incline obliquely in a northwesterly direction, crossing the St. Lawrence at Ogdensburg. Mr. Goodsell of Rochester collected a suit of specimens in the islands of the St. Lawrence, and on the main land, for a considerable distance into Canada. In the month of August and September, 1828, Lieut. Day, at the request of Dr. Zina Pitcher, collected a series of rock specimens from lake Huron to Montreal, on both sides of, and upon, the mountain ridge, which runs along the north side of the great chain of lakes. These specimens I have before me. Also a suit collected by Dr. Pitcher himself, presenting the entire geology of the whole circuit of Lake Superior. I am now prepared to inform American geologists, that the McComb Mt. range of primitive rocks extends in a northwest direction, forming the north-eastern boundary of the great lakes; at least to the distance of one thousand miles from the St. Lawrence at Ogdensburg. I intend to give a general account of the geology of those northwestern regions, in the course of the year, in Silliman's Journal, from specimens and by the aid of Dr. Pitcher of the U. S. Army, unless that gentleman will himself undertake it.

and numerous other localities, seem to authorize the adoption of the opinion of De Witt Clinton, LL. D. Professor Nuttal, and several Europeans, who prefer including the granite and gneiss of Werner under the general name, granite. Varieties. *Sandy*, at Little Falls. *Porphyritic*, in Johnstown, Montgomery county, N. Y., Litchfield, Connecticut; Chester, Massachusetts. *Graphic*, in Litchfield, Conn. and Southampton mines. Contents. *Steatite*, in Savoy. *Diallage*, Lake George. *Magnetic iron ore*, Crown Point on Lake Champlain. Plumbago in beds almost co-extensive with the stratum.

Plumbago.

2. Mica-Slate, is an aggregate of grains of quartz and scales of mica. Subdivisions. *Compact*, when the slaty laminæ are so closely united, that it will present an uniform smooth face when cut transversely. *Fissile*, when the laminæ separate readily by a blow upon its surface.

Localities. *Compact*, on the Boston stage road between Worthington and Chesterfield, and between Shrewsbury and Northborough, Massachusetts. *Fissile*, Fort Montgomery in the Highlands; Conway, Massachusetts. Contents. *Staurotide*, Litchfield, and Goshen, Connecticut. *Sappare*, Chesterfield, Massachusetts; Chatham, Connecticut. *Garnet*, every where, and often plumbago.

Plumbago.

Primitive hornblende rock and felspar.

3. Hornblende Rock, is an aggregate, not basaltic, consisting wholly, or in part, of hornblende and felspar. Subdivisions. *Granitic*, when it presents the appearance of crystalline granite with hornblende subsituted for mica. *Slaty*, when of a rifty or tubular structure. Varieties. *Gneisseoid*, when it resembles slaty granite (gneiss) with scales of hornblende substituted for mica. *Greenstone*, when of a pretty uniform green colour, and containing but a small proportion of felspar, generally of a slaty structure. *Porphyritic*, when spotted with cuboid blocks of felspar. *Sienitic*, when speckled with small irregular masses of felspar.

Localities. *Slate*, east part of Becket, Mass., Butterhill, in the Highlands. *Granitic*, Dalton, Mass., Highlands, adjoining the granite. Varieties. *Gneisseoid*, Dalton, Mass. Butterhill, Highlands. *Porphyritic*, Conway, Plainfield, Buckland, Mass. *Sienitic*, Clip Hill, Johnstown, N. Y. and near Boston, Mass. Contents. *Granite*, in veins, Belchertown, Mass. *Actynolite*, Cummington, Mass. *Augite*, Lake George, N. Y. Rarely plumbago.

Whetstones or novaculite.

4. Talcose Slate, is an aggregate of grains of quartz and scales of mica and talc. Subdivisions. *Compact*, having the laminæ so closely united that a transverse section may be wrought into a smooth face. When the quartzose particles are very minute and in a large proportion, it is manufactured into scythe-whetstones, called Quinnebog stones. *Fissile*, when the laminæ separate readily by a blow upon the surface. Varieties. *Chloritic*, when coloured green by chlorite. In some localities the chlorite seems to form beds ; or rather the rock passes into an aggregate, consisting of quartz, mica, talc, and a large proportion of chlorite. Vast beds of pure chlorite are embraced in this rock on Deerfield river, in Florida, Mass.* and in Windham, Vt.

Localities. *Compact*, east side of Saddle Mountain Range. *Fissile*, on the west side of the same range. Variety. It is highly coloured with chlorite in the east part of Savoy. Contents. *Chlorite*, in beds in Savoy and Florida, Mass. containing Octahedral crystals of iron ore, also, near Williams College, Mass. It contains gold in the Carolinas, and probably throughout its whole range by way of New-York, to Canada.

* I have recently examined the talcose slate of Florida, Mass., where it crosses Windham, Vt. It does, absolutely, pass into the great soapstone quarry of that town ; which is green near its western side, eighteen miles west of Connecticut river. From fourteen to eighteen miles west of Connecticut river are the most extensive manufactories of this quarry stone, probably, in the world. This stone is certainly a compact variety of the talcose slate of Massachusetts, extending to this place. The beds of soapstone in slaty and crystalline granite, both at Westfield, and Florida, Massachusetts, always connected with serpentine, misled Messrs. Hitchcock and Davis. See Silliman's Journal, in which both these very industrious zealots in useful science, mistake the fine slaty variety of granite (gneiss) for mica-slate. There is but very little mica-slate in New-England. The rocks of that district are chiefly gneiss and talcose slate. I venture to commit myself on this point, because I have carefully compared all the alternations of it from the New-York line to the Atlantic, with specimens labelled by Prof. Strouve, during the summer of 1829.

1. Quartzose formation.

5. Granular Quartz, consists of grains of quartz united without cement. Subdivisions. *Compact*, when it consists of fine grains, so as to appear almost homogeneous; generally in large rhomboidal blocks. *Sandy*, when the grains are so slightly attached as to be somewhat friable. Varieties.—*Translucent*, when it is so compact and homogeneous as to transmit light. *Yellow*, when slightly tinged with iron (probably a carbonate.) *Ferruginous*, when an aggregate of minute crystals strongly coloured yellow or red with the carbonate or peroxyd of iron. There is a remarkable locality two miles north of Bennington village, in Vermont. Large masses may be found consisting of six-sided crystals, with six-sided pyramids on both ends.

Localities. *Compact*, adjoining the east side of Saddle Mountain Range. *Sandy*, on the west side adjoining the granular limestone. Varieties. *Translucent*, Snowy Mountains in Wallingford, Vt. *Yellowish*, most common. *Ferruginous*, Bennington, Vt. Pittsfield, Mass. Contents. *Haematite*, in Dalton, Massachusetts, three miles south of the village. *Manganese*, in Bennington, Vt.

1. Calcareous formation.

6. Granular Limestone, consists of glimmering grains of carbonate of lime united without cement. Subdivisions. *Compact*, when it consists of grains of nearly pure carbonate of lime, so closely united that it will take a polish. *Sandy*, when grains of quartz are aggregated with the grains of carbonate of lime, but so loosely as to be somewhat friable. Varieties. *Dolomite*, when it consists in part of magnesia, and is friable. *Verd-antique*, when it is variegated in colour by the presence of serpentine, giving it more or less of a clouded green.

Localities. *Compact*, Stockbridge, Mass. *Sandy*, west side of Pittsfield, Mass., on the Albany stage road. Varieties. *Statuary Marble*, Stockbridge, Mass. *Dolomite*, Barrington and Sheffield, Mass., Milford, Conn. Contents. *Tremolite*, Canaan, Conn. *Serpentine* and chromate of iron, Milford, Connecticut.

Class II. *Transition or Second Series.*

7. Argillite, is a slate rock of an aluminous character, and nearly homogeneous, always consisting of tables or laminæ whose direction forms a large angle with the general direction of the rock. Subdivisions. *Clay Slate*, when the argillite is nearly destitute of all grittiness, and contains no scales of mica or talc. *Wacke Slate*, when it is somewhat gritty and contains glimmering scales of mica or talc. Varieties. *Roof Slate*, when the slate is susceptible of division into pieces suitable for roofing houses and for cyphering slate. *Glazed Slate*, when the natural cleavages are lined with a black glazing.—This variety contains anthracite coal and marine animal relics, and ferns.* 2. Carboniferous formation.

Localities. Clay Slate, Williamstown Mountain Range, the bed and banks of the Hudson. *Wacke Slate*, overlying the clay slate, most of the way from Massachusetts line to three miles west of Cohoes Falls, in New-York. As this slate takes the same inclination with the clay slate, and differs widely from the horizontal (or 1st) graywacke, and as their meeting can never be ascertained, I have presumed to join them. Varieties. *Chloritic*. Both of the divisions are often coloured green by the chlorite in Rensselaer county. *Roof Slate*. That which splits freely into roofing slate, Hoosick, Chatham, N. Y., Water Gap of Delaware River, Pa. *Glazed Slate*, banks and beds of the Hudson from Fort Miller to near Newburgh, Water Gap of the Delaware. *Chloritic*, *red* and *purple*, varieties frequently occur near its junction with the primitive rocks. Contents. *Silicious Slate*, nearly black, and of different shades of green, in the glazed variety at Troy and a few miles below Albany, in extensive beds. *Basanite*, in the glazed slate near Hudson, Troy and Albany. *Anthracite*, beds in Newport, R. I., in Worcester, Mass., in Fort Miller, Troy and Fishkill; and in small quantities along Hudson River, for

* I found reeds in the anthracite coal at Worcester, Mass. Ferns have been found in abundance in the anthracite at Newport, R. I.

eighty miles. The borings at Ballston and Albany, about forty miles apart, are made in the same layers of argillite ; and carbonated water is found in both places. See Mrs. Griffith's Essays.

2. Quartzose formation.

8. First Graywacke, is an aggregate of angular grains of quartzose sand, united by an argillaceous cement, apparently disintegrated clay slate, spangled with glimmering scales; and is never above the calciferous sand rock or metalliferous lime-rock. Subdivisions. *Graywacke Slate*, when the grains are so fine as to give the rock a homogeneous appearance, and is susceptible of division, into thick or thin tables, by natural cleavages. *Millstone grit and grey rubble*,* when the grains are in part course, and more or less conglomerate, either white or grey, often very hard. Both subdivisions are often coloured green by chlorite.

Localities. The *slate* lies immediately on the inclined edges of the argillite from Canada to Georgia. It is remarkably curved and bent on the Mohawk, between the Cohoes and Schenectady, at Saratoga Lake, and at the entrance of the Delaware and Hudson canal. *Millstone grit*, the whole of Shawingunk Mts. *Gray Rubble*, the highest ridges between Massachusetts line and the Hudson. Contents. *Milky quartz* in the eastern part of Rensselaer county, accompanied with chlorite. *Calcareous spar* and *disseminated anthracite* (never in beds) throughout its whole extent. It becomes an excellent quarry stone in many localities ; and in others it is brittle and irregular. Often red and sandy.

Contains calc spar and disseminated anthracite.

2. Calcareous formation.

9. Sparry Limerock, consists of carbonate of lime, intermediate in texture between granular and compact; and is traversed by veins of calcareous spar. Subdivisions. *Compact*, when the masses or blocks, between the veins of spar

* *Rubble* being an uncouth word, but too well established to be rejected, I will state : that in common English it signifies a hard grey stone, in roads, of a spheroidal form, which causes the rumbling and jolting of carriages. Kirvan calls these stones, common graywacke, as opposed to graywacke slate. See Webster's Dictionary.

are sufficiently homogeneous and uniform to receive a polish. *Slaty*, when the rock is in slaty tables or laminæ, with transverse veins of calcareous spar. This rock is often cut into very small irregular blocks by the spar, which gives it the name of checkered rock.

Localities. *Compact*, about New-Lebanon Springs. *Slaty*, three miles south of the springs on the Hudson turnpike. Variety. *Checquered rock*, on the Little Hoosick, and near New-Lebanon Springs. Contents. *Chlorite* and *Calc. spar*, every where.

10. Calciferous Sandrock, consists of fine grains of quartzose sand and of carbonate of lime, united without cement, or with an exceeding small proportion. Subdivisions. *Compact*, when the rock is uniform, or nearly so, without cells or cavities. *Geodiferous*, when it contains numerous geodes, or curvilinear cavities; which are empty or filled with calc. spar, quartz crystals, barytes, anthracite, or other mineral substances different from the rock. Varieties. *Oolitic*, when it consists in part of oolite, of a dark colour, and harder than the kind which is common in the lias or oolitic formation of Europe, New-Jersey and Ohio.

Localities. *Compact*, Flint Hill. *Geodiferous*, at Flat Creek, west of the Noses. Varieties. *Oolitic*, near Saratoga Springs. *Sparry*, at Flat Creek. *Quartzose*, on the north side of the Mohawk, opposite Flat Creek. Contents. *Concentric concretions*, near Saratoga Springs. *Sulphate of barytes* and *anthracite*, on the West Canada Creek, six miles above its mouth, also at Little Falls. *Semi-opal*, connected with the quartzose variety. *Brown spar* and *Hornstone*, at Flint Hill. Coarse agate in large quantities, and fine fortification agate in small quantities at Flint Hill, and in the north hill opposite Spraker's Basin on the Mohawk. Also numerous quartz crystals with pyramids at each end and containing anthracite, in the same locality and near Rensselaer School in Troy. In some, anthracite is seen, floating in a limpid liquid.

Anthracite in quartz crystals.

11. Metalliferous Limerock, consists of carbonate of lime in a homogeneous state, or in the state of petrifactions. Subdivisions. *Compact*, when it contains but few petrifactions and is susceptible of a polish. *Shelly*, when it consists of petrifactions, mostly of bivalve molluscous animals. Variety. *Birdseye marble*, when the natural layers are pierced transversely with cylindric petrifactions, so as to give the birdseye appearance when polished. The true metalliferous limerock is always compact, as far as I have examined. But

Carboniferous limestone and cherty limestone.

the rock called the *carboniferous limestone* by Europeans, has, for an equivalent in this country, a covering of limestone, and, in some localities, it has a higher covering of cherty limestone; that is, limestone containing hornstone. An example may be found by tracing Catskill Creek from its mouth, about four miles. But it is separated by interposed carboniferous and quartzose rocks, where it passes through Albany county.

Localities. Compact, on East Canada Creek, Otsquaga Creek, and west of Little Falls. *Shelly*, Trenton Falls, north of Utica, Glen's Falls, twenty miles north of Saratoga Springs. Variety. *Birdseye marble*, is the compact, to which, when polished, the vertical encrinites give a birdseye appearance. All these kinds, terminating upwards in the cherty kind, may be traced from Catskill, by way of the Delaware and Hudson Canal, until they may be seen passing laterally under the carboniferous slate, which embraces the Carbondale and other coal beds along the Susquehanna, in Pennsylvania.

Class III. *Lower Secondary, or Third Series.*

3. Carboniferous formation.

12. Second Graywacke, is an aggregate of grains of quartzose sand, less angular than those of first graywacke, and generally contain some fine grains of limestone. It can scarcely be distinguished from first graywacke in hand specimens; but it is always above calciferous sand rock and metalliferous lime rock. Subdivisions. *Graywacke slate* when

of a slaty texture. *Millstone grit* and *Grey rubble*, when the grains are in part coarse and more or less conglomerated, either white or grey ; often very hard. 3. Quartzose formation.

Localities. The *slate* embraces the Carbondale and Lehigh coal of Pennsylvania, extends along the east base of Allegany and Catskill Mts. from Georgia to Lake Ontario, underlays Utica and Rome. In the valleys of M'Comb's Mt. it is the genuine limestone shale of Farey, where it contains remains of the trilobite or cancer, or both. *Millstone grit* overlays the slate from Lake Ontario to Little Falls on the Mohawk, and mostly caps the Catskill and Allegany Mts. along their eastern ridges, from Albany county to Georgia ; and the *grey rubble* accompanies, underlays, or embraces it throughout most of its whole extent. All the divisions are often red and sandy. Pennsylvania coal. Limestone shale. Millstone grit.

Remark. A distinct stratum called *old red sandstone*, and another called *millstone grit*, have been given by most geologists. But the latest European geologists very properly reject them. Because the red sandstone is found passing into all the three graywackes, and the millstone grit is found passing into all the three grey rubbles ; not as strata meeting at their surface, but as continuous rocks. I shall, however, describe the *red saliferous rock*, as separate from the second graywacke ; though I may hereafter follow those who may unite it with second greywacke. No red sandstone as a distinct stratum.

13. Saliferous Rock, consists of red, or bluish-grey, sand or clay-marle, or both. The grains of sand are mostly somewhat rounded, and all the varieties of this rock in some localities, form the floor of salt mines and salt springs. Subdivisions. *Marl-slate*, when the rock is soft slaty, and contains minute grains of carbonate of lime. *Sandy*, when it is in solid blocks or layers, consisting of red or bluish-grey quartzose sand. Varieties. *Grey-band*, the uppermost layers of bluish-grey sandrock. *Conglomerate*, (breccia) consisting chiefly Salt springs

of rounded pebbles, red, grey, or rust-colour, as under the superincumbent rocks at Mount Holyoke, the Palisades, on the Hudson river, &c.

Localities. Its bassetting edges lie directly on the millstone grit. Both divisions, and all the varieties, but the conglomerate, may be seen at Genesee Falls and in the banks of the Niagara river ; also at Oak Orchard Creek. The conglomerate and sandy varieties are seen on Connecticut river, and at New-Haven under the basalt ; also on the Hudson above New-York under the pallisadoes. Salt springs are found in it every where west of Rome ; but none have been discovered under the basalt of this country.

Subordinate series. 14. Ferriferous Rock, is a soft, slaty, argillaceous, or a hard, sandy, silicious, rock, embracing red argillaceous iron ore. Subdivisions. *Slaty*, consists of green, or bluish-green, smooth soft slate, generally immediately under the layer of red argillaceous iron ore. *Sandy*, consists of a grey, or rusty-grey, aggregate of quartzose sandrock, in compact blocks or layers, overlaying or embracing red argillaceous

Ferriferous. iron ore. Variety. *Conglomerate*, consists of rounded pebbles, cemented together by carbonate or oxyde of iron, or adhering without cement.

Localities. It reposes on the saliferous rock every where west of Little Falls. The sandy division lies over the slate, and a layer of red argillaceous iron ore, about a foot or a foot and a half in thickness, lies between them ; or alternates with the layers of one or both. The slaty division is generally green or blue, and very soft. The sandy division is harsh, coarse, and often conglomerate at the top. The softest variety of the iron ore is called reddle, and is used as a paint.

15. *Lias*, is an argillaceous limestone, with an admixture of magnesia, iron, and finely pulverized quartz ; forming a compound of a homogeneous aspect. Subdivisions. *Argillaceous*, when it approaches the character of clay slate. *Cal-*

careous, when it approaches the character of limestone. On burning and mixing, as in the manufacture of mason's mortar, it becomes a solid cement under water. Water limestone.

Localities. It extends along the stage road from about 30 miles west of Utica to near Genesee river; a distance of about 130 miles—also at Lockport. Contents. *Gypsum* and the *vermicular limestone* are found in beds in this rock and in no other. All may be seen at Manlius Centre, along the south bank of the canal. *Shell limestone* is common in this stratum. One of the best localities is between the lower Genesee Fall and the one next above it, on the west side. Gypsum.

Shell grit is generally reposed on the upper surface of the lias. But it belongs to the quartzose formation of the third series. See the profile section on the map and the synopsis.

16. Geodiferous Limerock, consists of carbonate of lime, combined with a small proportion of argillite or quartz in a compact state, mostly fœtid, and always containing numerous geodes. Subdivisions. *Swinestone*, when it contains very little or no quartzose sand, is irregular in structure, fœtid and abounds in geodes. *Sandy*, when it contains quartzose sand, is stratified, scarcely fœtid, and contains but few geodes. 3. Calcareous formation.

Localities. *Swinestone* is found in the bed and banks of the Erie canal near Genesee river, and extending one mile east. The canal at Lockport it cut through this rock to the depth of nearly thirty feet, for two miles. It forms the upper part of Niagara Falls to the depth of seventy feet. The *sandy division* overlays the swinestone. Its characters are well exhibited at Black Rock, immediately under the cornitiferous limerock. Here it contains malachite and magnesia, as constituents. Specimens of this rock, after lying a year in a damp cellar, shoot out numerous crystals of Epsom salts.—Varieties. The *fetid* can scarcely be considered a distinct variety. The darker the colour, the more fetid the odor. Contents. The geodes contain *sulphate of strontian*, *granu-* Fetid, or swinestone. Contains magnesia and copper. Minerals in geodes.

lar gypsum, laminated selenite, anhydrous gypsum, fluor spar in limpid cubes, *arragonite, dog-tooth spar, brown spar,* and *waxy blende. Galena* has been found in small masses imbedded in this rock, and *bitumen* has been observed in exudations upon its surface, and in geodes.

17. CORNITIFEROUS LIMEROCK,* consists of carbonate of lime, embracing hornstone. Subdivisions. *Compact,* when the rock is close-grained ; and it generally contains hornstone in layers. *Shelly,* when it consists of shells and contains hornstone in nodules or irregular masses.

Extends up the lakes.

Localities. Black Rock affords an excellent locality of the *compact,* and Auburn, behind the state prison, presents a most perfect locality of the *shelly.* This stratum has been traced from Lake Erie to the Helderberg in Albany county. It has been traced up the Cayuga and Seneca lakes ; and, from the head of the latter, up Catharine Creek, by Engineer Hughes, But it has not been traced under the Tioga coal beds ; though Mr. Hughes found it at a level, which seemed to demonstrate that it must run several hundred feet beneath that formation. Possibly it may unite with the cherty limerock, which forms the upper surface of the metalliferous limerock, and which underlays the Carbondale coal. If so, the anthracite of Carbondale and the bituminous coal of Tioga, are in the same carboniferous formation. However, these strata are certainly separated by greywacke rocks at the Helderberg in Albany county, several hundred feet in thickness. See both profiles in the map ; particularly the exhibition of the cuneiform termination of strata.

Underlays Tioga coal.

Top of the Helderberg

CLASS IV. *Upper Secondary, or Fourth Series.*

4. Carboniferous formation.

18. THIRD GRAYWACKE, is an aggregate of grains of quartzose sand, less angular than those of first and second graywackes, and generally contains fine grains of limestone ; and

* I regret that I introduced this name. I had not then seen the name *Cherty limerock* applied to this stratum. Dr. Bixby has very properly applied it to this very rock ; and Bakewell applies it indirectly. But cherty does not apply accurately to the *compact* kind.

always contains *iron pyrites* at greater or less intervals, which gives it the name of *pyritiferous slate* and *grit.* It is always above the upper cherty limerock. Subdivisions. *Graywacke slate*, (or *pyritous slate*) when of a slaty texture. *Millstone grit*, and *grey rubble*, when the grains are all or part coarse, and more conglomerate than those of the other graywackes, either white or grey, often very hard. 4. Quartzose formation.

Localities. The *slaty*, on the south shore of Lake Erie, on both shores of Seneca and Cayuga lakes. It embraces the bituminous coal of Tioga, and the bituminous shale and thin layers of the same coal near the heads of Cayuga lake, Lake Erie, &c. *Millstone grit* and *grey rubble*, accompany each other (the grit generally overlaying the rubble, though they alternate sometimes) along the whole extent of the western ridges of the Catskill and Allegany Mts. the grit generally capping the ridges, and defending them from the action of the disintegrating agents. Both divisions are often red and sandy. Nodules of a kind of wacke are often found in the slaty kinds, which contain bitumen in a waxy state. Embraces Tioga coal. Rubble and grit. Caps the Allegany Mts.

19. Oolitic Rocks, are aggregates, which contain more or less of carbonate of lime of an earthy texture, either compact and white (chalk) or in minute concentric spheres, (oolite) or combined with fine grains of quartz, (silicious.) The subdivisions, silicious limestone, oolite and chalk, are characterised in the preceding definition. 4. Calcarious formation.

Localities. *Silicious limestone* is found in place, in fields, or in large boulders, every where on the western ridges of the Allegany. They are generally dark-brown or black, and the limestone part is disintegrated at the surface; leaving the quartz only, which seems to be blackened by the disintegration of the pyrites. *Oolite* has been found in the town of Franklin, Bergen county, N. Jersey, by Dr. Horton—also in Ohio state. The *chalk* has not hitherto been found in America; but it abounds in various parts of Europe, associated with the silicious limestone and oolite. Silicious limestone. Oolite. No chalk found in America.

Class V. *Tertiary, or Fifth Series.*

5. Carboniferous formation.

20. Plastic Clay, that kind of clay, generally called potter-baker's clay, which will not effervesce with acids. When it is white it is called pipe-clay.

Plastic clay in N. Jersey.

Localities. On the south side of the bay of Amboy in N. Jersey in a vast stratum of many miles in extent. It appears near the water-edge of Lake Champlain at Crown Point, &c. The pipe-clay variety is seen, like a bank of snow, at the west end of Amboy bay.

Contents of marly clay.

21. Marly Clay, that kind of clay, which will effervesce with strong acids. It overlays the plastic clay aforesaid, when it embraces, near its lower surface, the lignite, iron-stone, bog-ore, iron pyrites, &c. Farther east (in New-Jersey) it embraces a kind of marl, which contains numerous animal remains, both oviparous and viviparous vertebrated, as well as radiated and Molluscous. The marly clay does not generally embrace the marl-beds, which contain organic relics. Even in New-Jersey it contains no organic relics, where the marl-beds are wanting. The iron, both bog-ore and iron-stone, are found in all parts of this stratum from Lake Champlain to Greene county, on the west side of the Hudson, a distance of about 100 miles.

Very extensive.

Localities. This stratum is almost universal. It is found in every part of the earth when it is sought in situations where it is not subject to be washed away. It always, probably, contains muriate of lime; consequently, all wells dug in it contain hard waters.

5. Quartzose formation.

Crag.

22. Marine Sand and Crag. The *sand* consists of fine grains of quartz, not united by adhesion or cement; but in loose masses which may be poured—the *crag* consists of pebbles, clay and loam, either united by a carbonate of lime or iron cement, as *puddingstone;* by clay and iron cement, as the *hardpan*; or not united, being merely *stratified gravel;* or united by adhesion, as the reniform *arenaceous concretions* near Troy, on Green Island, &c.

Localities. The *marine sand* occupies a broad strip on the west side of Hudson river, from near Lake Champlain to Greene county; a distance of one hundred miles—also the north part of New-Jersey, most of the eastern part of the Southern States, the valley of the Mississippi, &c. According to Dr. E. James, the marine *sand* and *crag* extend over about four hundred thousand square miles of the great desert between the Mississippi and the Rocky Mountains.

5. Calcarious formation.

23 SHELL-MARL, is in insulated or continued layers, fields, or patches, in almost every part of the earth. It generally reposes on marine sand or crag in all bottom grounds; particularly in graywacke districts, as in every part of the Catskill and Allegany range. It is still more abundant in the western valleys of New-York, Mississippi, &c. It may be seen in depressions on primitive rocks, as in Pittsfield, Mass. &c. It consists chiefly of broken, pulverized, and entire shells, of the genus *helix* (genera *helix*, *planorbis*, and *lymnaea* of Lamarck.) Calcarious tufa is often in beds in the shell-marl; which proves it cotemporaneous with it. Consequently the embraced plants of this tufa are antidiluvial. But tufa is *now* forming in many localities.

Contents of shell marl.

ANOMALOUS DEPOSITES.

I. VOLCANIC. Subdivisions. BASALT, which is either, *Amygdaloid*, when amorphous, of a compact texture, but containing cellules, empty or filled. *Greenstone trap*, when of a columnar structure, or in angular blocks, often coarse-grained. Variety. *Toadstone*, when the amygdaloid has a warty appearance, and resembles slag. VOLCANIC PROPER, as *Lava*, when dark coloured and nearly homogeneous. *Breccia*, cemented grains. *Trachyte*, white or grey lava, consisting chiefly of melted felspar, as pumice, &c.

Lava and trachyte.

Localities. Of the *basalt* every variety, and every imbedded and every disseminated mineral, may be seen at Deerfield and at Mount Holyoke in Massachusetts; at New-Haven in Connecticut, and at the Palisadoes on the river Hudson. It appears from the observations of Dr. Z. Pitcher, and of Mr. Schoolcraft, that it once existed in large quantities on Lake Superior; and Dr. E. James found numerous table rocks of basalt, between the Mississippi and Rocky Mts.* The *lava*, in all its varieties, is in abundance at Vesuvius in Italy.

Along Erie canal.

II. Diluvion. Deposites made by the deluge. Subdivisions. *Proper diluvion*, along the Erie Canal, from Little Falls to near Genesee River—also, under the city of Troy south of the culvert. *Ultimate diluvion*, in all the ancient elevated forests of New-Hampshire, Vermont, Connecticut, &c.

III. Post diluvion. Subdivisions. *Gravel* or *pebbles*, forty feet in depth, form the bed of the Hudson from the head of tide water at Troy to near Albany. Seven miles below sediment more or less fine is seen in the bottom of the river.—Dr. Hayden, of Baltimore, has given numerous localities of this kind, without any other object than that of giving us simple truth.

Works of art.

Works of art are found in this formation, which distinguishes it from diluvion. It is a curious fact, that no works of art are found in the diluvion. It seems to prove, that durable works of art were not common before the deluge; and that pasturage was the chief employment of the antidiluvians.

IV. Analluvion. This is the detritus, formed by the disintegration of the exposed surface of all rocks, and remains on or near the place of disintegration. Subdivisions. *Argillaceous*, when the detritus is fine and adhesive. *Granulated*, when in coarse grains, or friable. The character of the soil thus made depends on the character of the rock disintegrated.

Depends on underlaying rock.

This is the only kind of soil, which is dependent on the underlaying rock for its character.

* I received a complete suit of Basaltic specimens, with their most important associations, from Nova-Scotia; obligingly presented by Messrs. Alger and Jackson, of Boston. They are precisely like those of the Connecticut and Hudson rivers. See Silliman's Journal. I rejoice that Boston contains at least two "*matter-of fact*" geologists. Ignorant puffing reviewers look too small for a town, so long most pre-eminent in *literature*.

DESCRIPTION OF THE MAP, IN REFERENCE TO USEFUL MINERALS.

Slate Colour. No. 1, 2, 3, 4, 5.

This colour indicates the formations, which contain beds of *carbon.* These beds are, 1. *Carburet of iron* (plumbago) 2. *Anthracite*, (coal without bitumen,) 3. *Coal*, (containing bitumen,) 4. *Coal of a sulphurous character*, (containing iron pyrites,) 5. *Lignite*, (presenting the form of wood.)

Yellow colour. Quartzose formation, less useful than the other two formations. When this rock is divided into blocks, by natural cleavages, (as granular quartz in most cases,) it is used for quarrying; otherwise it is not used on account of the labor of cutting. In some localities, these rocks are red and sandy. They are then wrought under the name of freestone. Saliferous rocks belong to this formation, but they are placed under the red colour.

Blue colour. Carbonate of lime (limestone, pure carbonate of lime, or more or less silicious.) The compact is always useful, as marble, under the names statuary (granular,) birdseye (with nearly verticle encrinites,) or *varigated*, (when its colours are mottled, whether statuary, birdseye, or amorphous.) All kinds of limestone may be manufactured into mason's lime by burning. If a large proportion is quartzose, it makes an indifferent hydraulic cement. The genuine hydraulic cement (water limestone of Engineer C. White,) should contain a proportion of iron and magnesia.

Red colour. Sand-rock or marl-slate. These rocks are hard and silicious, or soft and slaty. They are always red or bluish grey. They belong to the quartzose formation of the third series, but they are of sufficient importance for a distinct colour. All the salt springs of North America are in this rock;* and all the American basalt rests on it.

* The Licks of muriate of lime and soda do not belong to this formation; but are often found in transition districts, &c.

GREEN COLOUR. Ferriferous rocks and lias. Ferriferous slate underlays, and ferriferous grit overlays, the vast stratum of red argillaceous iron-ore. The lias overlays both, and embraces the gypsum and shell-limestone. It is the true lias or hydraulic cement, as above stated.

GREEN SPOTS. Basaltic rocks; which have been used, after burning, for water cement. Agate, chalcedony and other gems, are found in this rock.

BLUE SPOTS. Shell-marl, when of the fifth series ; which is a most excellent manure on silicious and clay soils. It is burned for mason's lime in the Allegany mountains.

When BLUE SPOTS are made in the yellow colour, which does not overlay the fifth quartzose yellow, it is intended to represent the oolitic formation, reposing on the fourth quartzose formation. It then represents the fields of *silicious limestone* which repose on the quartzose formation of the fourth series ; being the lowest layer of oolitic formation. It may also represent the oolite which lies on the silicious limestone in New-Jersey and Ohio, and the chalk of Europe.

DESCRIPTION OF THE PROFILE SECTIONS ON THE MAP.

1. *From Jefferson County, N. Y. to Northampton County, Penn.* 2. *From Niagara Falls to Sandy-Hook.*

The district of country embraced in this map, gives the geologist three remarkable views of the order of superposition among the strata. First, along the Erie canal line, from east to west. A profile section of which I published in 1824. Second, along the west side of the Hudson river, at a greater or less distance from it; a section of which is given at the top of the map. Third, from Niagara Falls to Sandy-Hook ; a section of which is given at the bottom of the map.

The section at the top of the map, is intended to represent the lateral wedge-form terminations of strata. Their precise termination cannot be ascertained. But we see them in thick strata in the heights along the west of the Hudson. And their gradual diminution, and final termination by the meeting of the continued strata, as here represented, as manifest farther south. Whether we ought to consider these as vast beds, or subordinate strata, or depart from the Wernerean plan, by treating them as strata, (on account of their vast extent) and introduce the *lateral cuneiform* termination, I leave for further discussion.

The section at the bottom of the map, is intended to represent all the five series of formations. As the precise lateral termination of the subordinate strata can not be ascertained, this section must be considered as applied in any part of a belt of forty or fifty miles in breadth. Lines are drawn on the top section to represent the places assigned to this section, and to that which was published in 1824.

It is manifest that the numerous strata of the middle of this district are reduced to about four general strata, somewhere in Pennsylvania. It is to be hoped that future examinations may settle those limits accurately. And it may be an important subject of enquiry, whether the whole series which seems to terminate somewhere in the north part of Pennsylvania, should not be treated as subordinate.

☞ For references to kinds of soil, see Soil.

HISTORY OF THE CREATION OF ORGANIZED BEINGS, IN REFERENCE TO THE FIVE GEOLOGICAL SERIES.

1. First Series.

No organized beings have been found in this series. Hence we infer, that granite, mica slate, hornblende rock, talcose slate, granular quartz, and granular limestone, had all been deposited and become indurated, before any plants or animals had been created. No organized relics.

2. Second Series.

No organized beings in lower argillite.

No organized beings have been found in the lower parts of the argillite. Hence we infer that so much of the argillite had been deposited, before organized beings had been created.

Acotyledonous and culmiferous plants, some radiated and molluscous animals.

Near the middle of this stratum, we find anthracite, containing ferns and a few reeds, as in Providence, Rhode-Island, and in Worcester, Massachusetts. At the surface, and in the wacke slate division, we find terebratulites, as at Waterford, New-York; and the orthocerite, as in Troy. Hence we infer, that acotyledonous stiped and culmiferous plants, bivalve mollusci and chambered univalves were created with or before the depositions of the last of the argillite—the acotyledonous and monocotyledonous plants before the animals.

Land relics.

As the ferns and reeds found in the argillite, appear to be the production of land, not under water, (though they may have grown in fens or marshes) the ocean must have retired before they were created. And as the terebratulites, orthocerites, &c., are marine productions, the oceanic waters must have retired after ferns and reeds had grown. Because we find marine organic relics only in the two formations overlaying the argillite, we infer that oceanic waters covered the earth, until all transition strata were deposited after the ferns and reeds of the argillite were made.

Marine relics.

3. Third Series.

Monocotyledonous land plants.

In the carboniferous formation of this series, we find coal, not bituminous, as in Carbondale, Penn., containing cane, palms, &c. Bituminous coal is found in this stratum, in Europe. Hence we infer that monocotyledonous, culmiferous and stiped plants, of land growth, were created soon after the transition series was completed. Over the carboniferous formation we find marine animal relics only, to the end of this series. Hence we infer that the oceanic waters again returned, and continued for a considerable time on the earth.

Marine animals.

4. Fourth Series.

In the carboniferous formation of this series, we find bituminous coal, containing the same land plants, of the monocotyledonous culmiferous kinds; but no dicotyledonous or cauline plants. Hence we infer, that although the plants of the culmiferous kinds increase in proportion, none of a more complicated family were yet created. But immediately over the carboniferous slate, we find oviparous vertebral animals. I have before me the relics of a crotalus, found by Dr. Rose of Montrose, Penn. Hence we infer, that oviparous vertebral animals were created soon after the bituminous coal deposites were made. Over the last stratum, we find marine relics again. Hence we infer, that the oceanic waters returned a third time, and continued for a long time on the earth.

Monocotyledonous land plants.

Marine animals and oviparous vertebral animals.

5. Fifth Series.

All the strata of this series are still soft, or semi-indurated. In this carboniferous formation, consisting of plastic (potter-baker's) clay, and marly clay, we find coal, which consists merely in charred dicotyledonous cauline plants. That these strata are very ancient, is manifest from their containing immense quantities of well stratified iron-stone, bog-ore, and reniform pyrites.

Dicotyledonous land plants.

In the same *geological* level, we find beds of a kind of marl, containing viviparous vertebral animals. But when such beds are wanting, as near Albany, in most of Vermont, &c., no such relics are found.

Marine animals and viviparous vertebrals.

It may be proper to add, that animal relics found in diluvion, though of anti-diluvial species of course, are of a more recent character than those found in the tertiary formation. Most, perhaps all, of the relics found in the tertiary, are extinct species. Whereas those of the diluvion are frequently either of species now living, or very nearly related to those which are.

Animals more recent in diluvion than in tertiary.

But we find marine organic relics intermingled with the land relics, in the carboniferous formation of the fifth series, (tertiary.)

Alternations of land and water.

From these and other established facts, we are authorized to infer, that the waters of the ocean have covered the earth and retired alternately, several times, (at least three or four times) and remained for many years, or even centuries, each time.

Hypothesis of alternations of land and marine relics.

A satisfactory account of these alternations has not been given, as to the particular times or the causes. But it may not be at variance with fact to imagine, that the waters retired at the termination of each calcareous deposite, and that land plants sprung up immediately after, calcareous strata always being uppermost. And that after a few centuries, the ocean again overflowed the earth, and enveloped the vegetables in *argillaceous* slaty deposites of argillite or graywack; which vegetables afterwards became charred and mineralized, forming coal. The *quartzose* and *calcareous* deposites followed. Again the waters retired, and again vegetables grew; and the whole process was again repeated. These alternating operations were repeated, until the five series were formed. Such a conjecture is in accordance with the known fact, that the calcareous deposites are all succeeded by land vegetables in slate rocks, mostly in a charred state. These rocks are preceded and succeeded by rocks containing marine relics.

Land plants always revived on calcareous deposites.

These hypotheses may perhaps be pursued in a future publication, wherein I may present facts towards a demonstration, that the calcareous formation has always been uppermost, when land plants grew. Also that in the present era of the earth's history, land relics have succeeded the last calcareous (shell marl) deposite of the last overflowing of the waters, which remained a sufficient time to become quiescent. The last, or Noahean deluge, must be considered as an extraordinary occurrence; not produced according to the ordinary course of events. That deluge greatly disturbed the shell-marl deposite, and forced it into fields and patches in hollows, low vallies, &c. If the relics contained in the shell-marl should be considered as those of fresh water, it might render the hypothesis more complicated; but I cannot perceive that it would be a substantial objection.

SOILS,

As influencing the growth of Vegetables.

An error of importance had prevailed among geologists, on the subject of the origin of soils, until a classification of detritus was established. Cuvier's theory of the earth did much towards the present improved state of that department of geological knowledge. But Schoolcraft suggested the first thought ever published, on a classification, which is in accordance with the present views of geologists on that subject; though his nomenclature was different.* Near the same time Conybeare, Buckland, and others, gave a character to it, which will endure.

Prevailing error.

Schoolcraft first suggested the distinction between tertiary and diluvion.

It seems to be demonstrated, that anti-deluvial detritus (called the tertiary formation) is a deposite, as independent and distinct, as secondary rocks. It cannot be traced immediately to any adjoining rocks. Consequently its character cannot be explained by referring to other strata; unless we admit the general principle that all deposites, made after the deposition of the lower part of the argillite, consist of fragments of the older rocks.

Tertiary an independent deposite.

The principle heretofore received then, that soils depend for their constituent characters on underlaying rocks, cannot be received any farther than as applied to *analluvion.* All other kinds of soil have characters as independent as transition or secondary rocks; and they may be classified now, with as mueh accuracy.

* See my Index to the Geology of the Northern States, 2d ed. 1820.

CLASSIFICATION OF SOILS.

Elementary Principles.

Ultimate elements no test of soils.

1. Fertility of mere earthy soils does not depend on their ultimate chemical elements. Pulverized emery, which is almost pure alumine, will have the same influence upon vegetation as pulverized quartz, which is nearly pure silex. Hence the reason that Davy, and other distinguished chemists, have disappointed agriculturists by their analyses; which were founded on such mistaken views.

Mere earthy soils, what is requisite.

Perfection of soils, require three qualities.

2. The perfection of earthy soils, without any reference to animal, vegetable, or other adventitious matter, requires the following constituents in due proportion: 1. *Stones* and *pebbles* sufficient to keep the soil open and loose. 2. *Clay* sufficient to absorb and to hold water in a just proportion. 3. *Fine sand* in sufficient quantities to prevent the clay from baking into a compact mass, in time of drought. Also to prevent its retaining so much water in the winter season, as, by expansion during the freezing of the water, to draw the roots of vegetables from the earth—called the winter-killing process.

Winter-killing.

To select or improve land.

To select a farm for purchasing, or to improve land by artificial means, without the application of manures, requires particular attention to these proportions.

Plants feed on air, by absorption of gases.

Vegetables receive their chief support from the atmosphere; and the whole of it, when they grow in clean, pure, umanured earth. Neither dry sand nor baked clay will absorb the nutritious gases. Duly moistened earth absorbs carbonic acid, ammonia, and other nutritious gases, which are received from the soil by the fibrous rootlets, for the use of plants. Charcoal and other carbonaceous matters, absorb these gases with great avidity. Hence the great value of carbonaceous manures, as rotted straw, charcoal, &c. But a due proportion of moisture is essential to absorption in all cases. Hence the importance of an attention to soils in reference to the absorption and re-

Carbonaceous manures.

Carbon and moisture produce absorption of gases.

tention of water. Hence too the importance of frequently stirring and disturbing the dry surface of the soil, in time of drought, by hoeing, plowing, &c., in order to present a moist surface to the atmosphere; without which, nutritious gases cannot be absorbed.

Carbonate of lime, sulphate of lime, and all the soluble salts, as well as putrifying vegetables and animals, should be considered as manures. They all act, either as absorbents, like charcoal; stimulants, like gypsum, muriate of lime, &c., or as furnishing nutritious matter by their decomposition, like fish, rotted straw, &c. Therefore the geological agriculturist studies chiefly the proportions of *stones*, *pebbles*, *clay* and *sand*. The study of that part of geology which relates to *detritus*, is the true study of the first principles of elementary agriculture.

Salt manures and organic matter.

Geology teaches agriculture.

By a reference to the system of classification, in the preceding part of this text-book, it will be seen, that all detritus is distributed into eight deposites. 1. Plastic clay. 2. Marly clay. 3. Marine sand. 4. Shell marl. 5. Diluvion. 6. Ultimate diluvion. 7. Post diluvion. 8. Analluvion. After studying the characters of these deposites, nothing more is required than a mere application of common sense to each particular case.

Eight elementary kinds of soil.

CHARACTERS OF THE EIGHT KINDS OF EARTHY SOILS, AND THEIR COMPOUNDS.

1. *Plastic clay.* This stratum is rarely found at the surface of the earth, excepting at its out-croppings in banks. It is destitute of any material portion of carbonate of lime—being the clay used by potter-bakers. Without any intermixtures, it would bake in the dry season, and be loose mortar in rainy weather. Intermixed with marine sand, it would be tolerably productive. Wheat winter-kills in it more than in any other soil.

Bad soil alone.

2. *Marly clay.* (London clay.) This stratum is almost universal in bottom grounds. Alone, it bakes in a drought, and is mortar in a wet season. Wheat winter-kills in it. But it generally contains from fifteen to twenty per cent. of carbonate of lime, and considerable muriate of lime. Wells dug in it, almost invariably furnish "hard waters," on account of the muriate of lime. These salts give it richness. Therefore if it is duly mixed with marine sand (which generally overlays it) it forms rich and very durable soil. From near Lake Champlain to Greene county, on the west side of the Hudson, this clay, overlayed with marine sand, prevails. Also throughout most of the northern part of New-Jersey, along the valley of the Mississippi, &c. If the vast plains of *marine sand*, between the Mississippi and Rocky Mts. are generally underlayed with this clay, as they certainly are in some localities, next century may, under the hand of culture, enliven that barren waste with fruitful fields.

Baking and winter-killing.

Contains hard water.

Mixed with marine sand

3. *Marine sand.* (Bagshot sand.) This stratum alone is a meagre barren soil. But makes an excellent kind when duly intermixed with the marly clay beneath it, as mentioned under marly clay. This stratum often passes into crag, or stratified gravel, hardpan, &c. The crag is a better soil alone, than the sand, excepting the hardpan and some other varieties, wherein the gravel is held together compactly by ferruginous, calcareous or clayey cement. But, if duly intermixed with the marly clay, it forms a good soil.

Bad soil alone.

Mixed with marly clay.

4. *Shell-marl.* This deposite is a most excellent manure, when intermixed with any of the other soils—best with soils in which clay predominates. It is chiefly carbonate of lime; but being made up of broken shells of minute species, it is always in a state suited to its application as a manure. But when alone, it is not very productive, especially in a dry season.

Good manure.

5. *Diluvion.* As this deposite is the most heterogenious of all deposites, it presents the characters of most other soils. In general it is very rich in vegetable manure; but it is often too

Very variable.

loose, and requires an artificial intermixture of clay. It presents all its characters along the Erie canal, between the Little Falls and the Genesee river. It frequently affords localities of vegetable mould, which may be advantageously carted upon other soils. As it is generally in narrow slips or small fields, the surrounding grounds may receive its benefits with but little carting. Along the Erie canal.

6. *Ultimate diluvion.* This seems to have been a thin universal mantle, covering the earth in the first ages after the deluge. It still remains undisturbed in the most ancient forests. But in all cultivated grounds, it has been intermixed with the underlaying soils. In its undisturbed state, it is the soil to which the word *loam* is most properly applied. Alone, it is a durable and rich soil, excepting where sand predominates. Mixed with other soils, it is always useful. Excellent alone or mixed.

7. *Post-diluvion.* Near the sources of the waters, which deposited this soil, it is always too coarse and destitute of any fertilizing quality—remote from these sources, it is fine and rich—midway between these extremities, it is middling in character. But post-diluvion is, from the nature of its origin, exceedingly variable—every locality depending on the deposites from which the waters flowed. Variable.

8. *Analluvion.* This kind of soil is perpetually forming by the disintegration of rocks, whose surfaces are exposed. Its character depends entirely on the constituents of the rock. Therefore argillite and argillaceous graywacke produce, by disintegration, clay soils. Rubble wacke, granular quartz, and other quartzose rocks, produce sandy soil. Hornblende rocks produce a rich intermixture.* Limestone rocks, particularly argillaceous limestone, as the geodiferous limerock, produce a rich calcareous and alluminous soil. Depends for fertility on the rocks beneath.

* Dr. E. James observes, (see Long's Expedition, vol. 2, p. 402) that in the midst of the Great Desert, near the Rocky Mountains, where all was "brown and desolate, as if recently ravaged by fire," the hills of greenstone trap, which consist essentially of *hornblende*, were covered with a green turf from their bases to their summits.

No rule is required for judging of analluvial soil, but to study the constituents of the rock, whose disintegration produces it.

Mixing elementary soils.

General remark. As these eight elementary soils are variously intermixed, by natural and artificial means, we have nothing to do in determining the characters of the various mixtures, but to examine the proportions of such of the elementary soils as enter into the composition of that which we have under consideration. [A simple process for determining these proportions, is given in a small duodecimo text-book, called Chemical Instructor, published by Websters & Skinners, Albany, 3d ed.]

LOCALITIES OF PARTICULAR SOILS, AS REPRESENTED BY COLOURS ON THE MAP.

Note. The soils are not referred to in the order of their scientific arrangement.

Ultimate diluvion. This yellowish grey loam is present in all level, or nearly level, places on the globe, unless washed away by post-diluvial waters. And it is always a thin outer coat or mantle, perfectly distinct and well characterized where no artificial or natural changes have been made since the deluge. It is remarkably distinct and well characterized in all the ancient elevated forests, of the *slate colour*, No. I. and IV., and the *yellow colour* west of the Hudson river. But whenever agricultural labor has been applied, it is so much intermingled with underlaying soils, and so much disguised by artificial and natural manures, that it can scarcely be recognized. When it reposes on that variety of crag, called hardpan, it remains distinct for centuries.

Analluvion. This kind of soil is next in extent over the surface of the earth, to the ultimate diluvion. For wherever rocks were left naked at the deluge, this is the only soil which covers them at the present day ; excepting those places where artificial works or post-diluvial waters have produced changes. It may be referred to on the map, under these subdivisions.—*Granulated*, consisting of coarse grains of graywacke. It is considerably fertile, and resists the effects of a drought. *Argillaceous*, or clay soil. Both subdivisions are more or less silicious. The *Argillaceous* soil is extensive in *slate colour*, No. II. III., and the lowest parts of IV. The *Granulated* soil in the elevated parts of *slate colour*, No. III. and IV., and in all the *yellow colour* where it is considerably silicious. But whenever the hardpan crag prevails, the underlaying rock is too well defended for disintegration, consequently there is no analluvion. The *argillaceous* kind is intermixed with *carbonate of lime*, so fine as to form a homogeneous mass in all the *blue colour*, where there is analluvion. The same reference may be made to all the *green colour;* though considerable magnesia is contained in the composition. The *red colour* is almost wholly granulated analluvion ; but it is too silicious, in most localities, excepting in low places, where other soil is washed down and intermixed.

Marine sand, crag and marly-clay. The marine sand and crag are always underlayed by marly-clay ; therefore they may be referred together. But they are in patches too limited for representing by any colours. Still, they are almost universal in all valleys, hollows and depressions of every kind in every part of the earth. These depressions may be in primitive rocks, thousands of feet high. And sometimes these strata are of great extent on elevated plains. But they are most conspicuous along the valleys of great rivers, as the Mississippi, the Hudson, &c.

All other soils, such as diluvion, post-diluvion, &c., are either too limited in their extent, or too variable in character, to be profitably referred to a coloured map.

SUMMARY REFERENCES TO SOILS, TO BE USED AFTER READING THE PRECEDING ENLARGED REFERENCES.

Ultimate diluvion. Slate colour. No. I. and IV.—Yellow colour west of Hudson river.

Analluvion.

Granulated subdivision, slate colour, No. III. and IV., all the yellow colour, and all the red colour.

Argillaceous subdivision, slate colour, No. II. and III., and lowest parts of No. IV., also intermixed with limestone in all blue colour and green colour.

N. B. It is but justice to say, that this attempt at a scientific arrangement of soils, was commenced by Dr. T. Romeyn Beck and myself, in the summer of 1820, while taking an agricultural survey of Albany county. And it was considerably extended by Prof. L. C. Beck, and myself, in taking the Rensselaer county survey, the year after. Being wholly original in the arrangement, its errors and defects are unsupported by the authority of names; consequently, it should not, and *will not,* be received without much caution and frequent revision. The same remarks will apply to a large proportion of this text-book.

TABLE OF EQUIVALENT STRATA.

☞ I cannot deem worthy of *imitation* the numerous subdivisions of some Europeans, into from fifty to ninety strata. I consider Bakewell the only author, *well known in America*, who has presented us with a rational system of generalization. The labors of A. Brongniard, Conybeare, De La Beche, and others, claim our high esteem; but *not our imitation*. In this table, I refer to the equivalents of Bakewell chiefly. But I consider my duty well performed, as the author of a text-book, if I refer *accurately* to any good foreign authority, even without citing the name.* Numerous European strata absurd.

1. GRANITE. *Same* in Europe—the slaty kind often called *gneiss*. Primitive.
2. MICA-SLATE. *Same* in Europe.
3. HORNBLENDE ROCK. *Same* in France, &c.
4. TALCOSE SLATE. *Same* in Europe, with subdivisions *steachist* and *chlonite slate*.
5. GRANULAR QUARTZ. *Same* of some, *quartz rock* of others.
6. GRANULAR LIME-ROCK. *Crystalline lime-stone, primary lime-stone, statuary marble*.
7. ARGILLITE. *Same* of some; *slate, clay-slate* of others, and *argillaceous shistus* of others. *Alum-slate* of some; but the alum-slate is found in argillite, and in 1st, 2d, and 3d graywacke. Flinty slate of some is always a bed or alternating layer in argillite. Inclined graywacke slate is the uppermost side of argillite, containing an increased proportion of silicious grains and spangles of mica or talc. Transition. Inclined wacke.
8. FIRST GRAYWACKE. *Same*. But as the English confound several rocks under this name, it may be said to be strictly equivalent to the French name, *thrausma*, fragmented rocks. Thrausma or fragmented rocks.

* I intend to pursue this subject much farther, in a future publication.

9. Sparry limerock.
10. Calciferous sandrock.
11. Metalliferous limerock.

These are all equivalent to the European *carboniferous* or *transition limestone ;* as they immediately underlay the slate rock, containing the greatest coal measures. In some localities they unite our lower *cherty* or *cavernous limerock*, which rests upon the metalliferous limerock, as in Catskill, in N. Y. Though all these constitute the same calcareous formation in this country, they present such well characterized distinctions, and are so extensive, they ought not to be united in the same stratum.

Different strata, but same formation.

12. Second graywacke. The slate is called *limestone shale ;* and the millstone grit and rubble are called the same.—As this stratum is often confounded with the first graywacke, by the English, the *psammite* of Brongniard, may be given as its genuine equivalent. It is called *slate clay* and *coal grit*, by De La Beche.

Lower secondary.

Psammite is the only true foreign name.

13. Saliferous rock. *Saliferous sandstone* and *red marl, variegated sandstone.*

14. Ferriferous rock. No equivalent has been observed in Europe, excepting in limited masses, which have not been arranged among general strata. Its vast extent here demands a place in the system. The lower part of the European lias is sometimes red and grey, and highly ferruginous ; which may be a trace of this stratum.

No equivalent in Europe.

15. Lias. *Same.* It is also found to be, in many places, the true *water-setting lime* and *alum shale ;* precisely like the European. It also contains pseudomorphous crystals, imitating muriate of soda.

Water cement.

Common salt crystals.

16. Geodiferous limerock.
17. Cornitiferous limerock.

Upper carboniferous limestone. *Upper cherty* limestone. *Swinestone.* Perhaps this has no distinct equivalent in Europe ; or it may be equivalent to the upper carboniferous, separated by the interposed underlaying rock. It seems to agree pretty well with Buckland's description

Cherty and swinestone.

of the rocks of Kirkdale cavern, and he refers to an under part of it, which considerably resembles the geodiferous limerock.

18. Third graywacke. *Pyritus shale* and *grit.* This stratum seems to be in the same situation with the limestone beneath it, in respect to foreign equivalents. Perhaps it may agree with the *mimophyre* of Brongniard. See the profile section at the top of the map.

19. Oolitic rocks. Our *silicious fields of limestone* on the Allegany Mts. may be the *jura limestone. Oolite* the *same.* No chalk discovered in North America.

20. Plastic clay. *Same.*

21. Marly clay. *London clay.*

22. Marine sand. *Same,* and *bagshot sand.*

23. Shell marl. *Same.*

24. Volcanic rocks. *Same,* and *basalt, trachyte* and *trap rocks.*

25. Diluvion. *Same.*

26. Ultimate diluvion. *Same* in Europe, though never published by any geologist but American.

27. Post-diluvion. *Same,* but improperly called *alluvion* by some; as this is a generic name.

28. Analluvion. *Same* in Europe, though never published by any geologist but American.

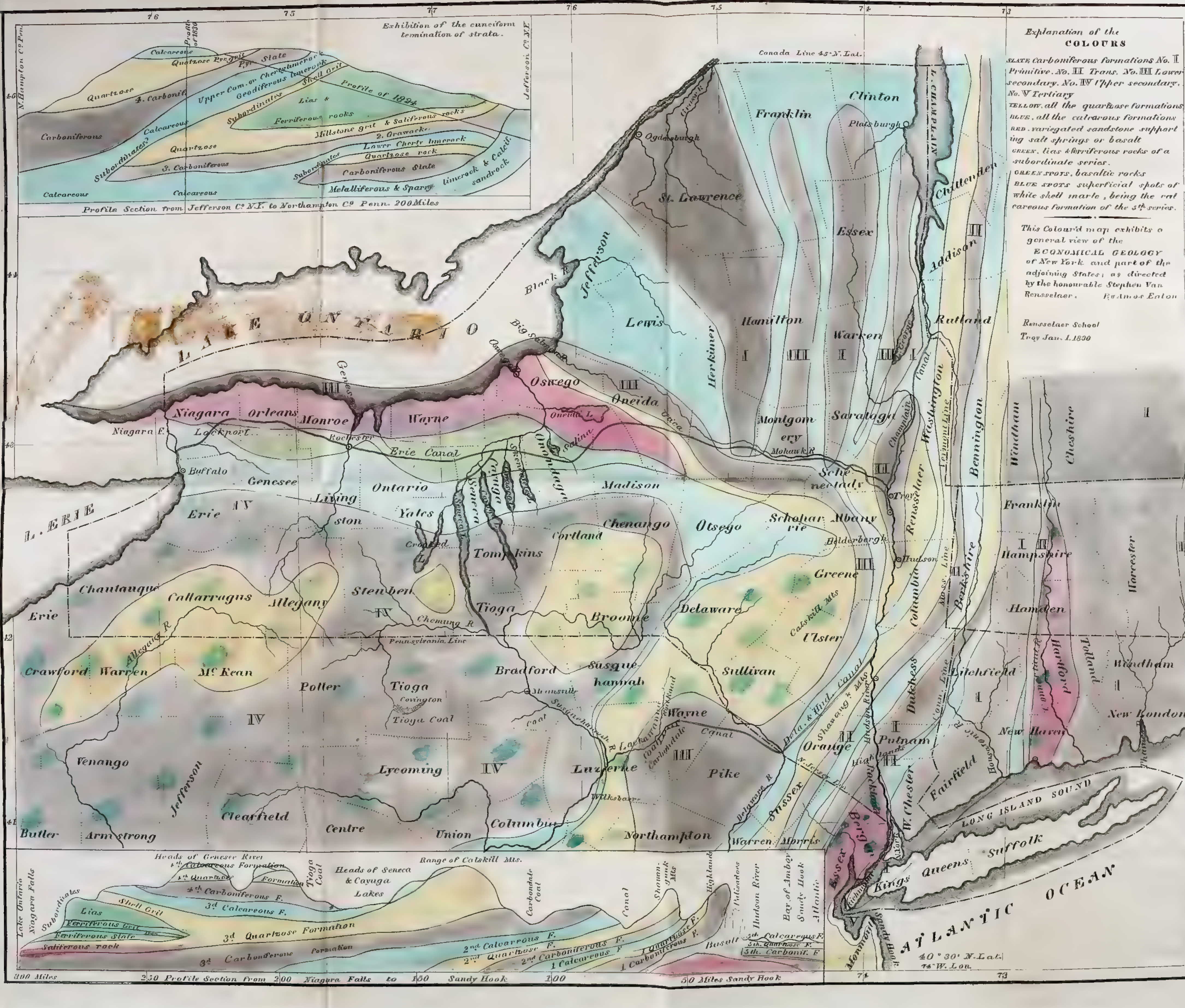
N. 1st. De Luc seems to have had an indistinct view of our ultimate diluvion and analluvion, when he introduced the name Geest.

N. 2d. It may be adopted as a general rule, that European strata present in many respects, more recent characteristics than their equivalents in America. There bituminous coal, for example, occupies the place of the Pennsylvania anthracite, &c. &c.

INDEX.

ERRATA.

Page 3, line 1, "Every geologist," should be, all geologists.
Page 9, line 10, "insolated" should be, insulated.
Page 23, on the Segment, the word Mississippi should be three-fourths of an inch farther west.
Page 32, line 9, from bottom, "tubular," should be, tabular.
Page 50, in the third paragraph, the second time "retired" is used, it should be, returned.



Explanation of the
COLOURS
SLATE Carboniferous formations No. I
Primitive. No. II Trans. No. III Lower secondary. No. IV Upper secondary. No. V Tertiary
YELLOW. all the quartzose formations
BLUE. all the calcareous formations
RED. variegated sandstone supporting salt springs or basalt
GREEN. lias & ferriferous rocks of a subordinate series.
GREEN SPOTS. basaltic rocks
BLUE SPOTS superficial spots of white shell marle, being the calcareous formation of the 5th series.
This Colour'd map exhibits a general view of the
ECONOMICAL GEOLOGY
of New York and part of the adjoining States; as directed by the honourable Stephen Van Rensselaer. By Amos Eaton
Rensselaer School
Troy Jan. 1. 1830
Exhibition of the cuneiform termination of strata.
Profile Section from Jefferson Cº N.Y. to Northampton Cº Penn. 200 Miles
Profile of 1830
Profile of 1824
N. Hampton Cº Pen.
Jefferson Cº N.Y.
Calcareous
Quartzose
Carboniferous
Subordinates
Lias &
Ferriferous rocks
Millstone grit & Saliferous rocks
Lower Cherty limerock
Quartzose rock
Carboniferous Slate
Metalliferous & Sparry limerock & Calcif. sandrock
Canada Line 45° N. Lat.
LAKE ONTARIO
L. ERIE
L. CHAMPLAIN
Erie Canal
Pennsylvania Line
LONG ISLAND SOUND
ATLANTIC OCEAN
40° 30' N. Lat.
74° W. Lon.
Clinton
Franklin
St. Lawrence
Essex
Jefferson
Lewis
Herkimer
Hamilton
Warren
Oswego
Oneida
Niagara
Orleans
Monroe
Wayne
Onondaga
Madison
Montgomery
Saratoga
Washington
Schenectady
Rensselaer
Albany
Schoharie
Otsego
Genesee
Erie
Livingston
Ontario
Yates
Seneca
Cayuga
Tompkins
Cortland
Chenango
Greene
Columbia
Chautauque
Cattaraugus
Allegany
Steuben
Tioga
Broome
Delaware
Ulster
Sullivan
Orange
Dutchess
Putnam
W. Chester
Kings
Queens
Suffolk
Chittenden
Addison
Rutland
Bennington
Windham
Cheshire
Franklin
Hampshire
Berkshire
Hamden
Hartford
Tolland
Worcester
Windham
Litchfield
New Haven
Fairfield
New London
Crawford
Warren
Mc Kean
Potter
Tioga
Bradford
Susquehannah
Wayne
Pike
Venango
Jefferson
Lycoming
Luzerne
Clearfield
Centre
Union
Columbia
Northampton
Butler
Armstrong
Sussex
Bergen
Essex
Warren
Morris
Tioga Coal
Catskill Mts
Profile Section from Niagara Falls to Sandy Hook
300 Miles
250
200
150
100
50 Miles Sandy Hook
Heads of Genesee River
Heads of Seneca & Cayuga Lakes
Range of Catskill Mts.
Lake Ontario
Niagara Falls
Lias
Shell Grit
Ferriferous Grit
Ferriferous Slate
Saliferous rock
3d Calcareous F.
3d Quartzose Formation
3d Carboniferous Formation
2nd Calcareous F.
2nd Quartzose F.
2nd Carboniferous F.
1 Calcareous F.
1 Quartzose F.
1 Carboniferous F.
Basalt
5th. Calcareous F.
5th. Quartzose F.
5th. Carbonif. F.
Hudson River
Bay of Amboy
Sandy Hook
Atlantic